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FUNGI THAT UTILIZE ZOOSPORES TO PARASITIZE NEMATODES

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INTRODUCTION: Most of the fungi that entrap nematodes possess sessile trapping devices. Entrapment by such fungi is contingent upon the victim migrating to the trap. In contrast, some nematophagous fungi produce zoospores which can migrate to the potential victim where attachment and infection occur.

Table 1. Genera and species of zoosporic fungi.

Genus and Species	Order	Zoospore Type (See Fig. 1)	Reference
Achlyogeton entophytum Schenk	Chytridiales	A	6
Achlyogeton rostratum rostratum Sorokin*	"	?	6
Bicricium lethale Sorokin	"	A	10
Catenaria anguillulae Sorokin	Blastocladiales	A	10
Catenaria auxiliaris (Kuhn) Tribe syn. Tarichium auxiliare	"	A	11
Catenaria vermicola Birchfield	"	A	5
Endochytrium operculatum (deWild.) Karling	"	A	10
Lagenidium caudatum Barron	Lagenidiales	E	3
Lagenidium parthenosporum Karling	"	E	3
Myzocytium anomalum Barron	"	E	10
Myzocytium glutinosporum Barron	"	E	4
Myzocytium humicola Barron & Percy	"	C	1
Myzocytium intermedium Barron	"	E	2
Myzocytium lenticulare Barron	"	E	3
Myzocytium megastomum de Wildeman	"	E	10
Myzocytium papillatum Barron	"	E	4
Myzocytium vermicolum (Zopf) Fischer	"	E	6
Nematophthora gynophila Kerry & Crump	Saprolegniales	E	8
Olpidium nematodeae Skvortzow	Chytridiales	A	12
Olpidium zootocum (Braun) Sorokin	"	A	10
Phlyctochytrium nematodeae Karling	"	A	10
Rhizophydium gibbosum (Zopf) Fischer	"	A	10
Rhizophydium vermicola Sparrow	"	A	10
Saprolegnia megasperma Coker	Saprolegniales	E	9

*Doubtful species

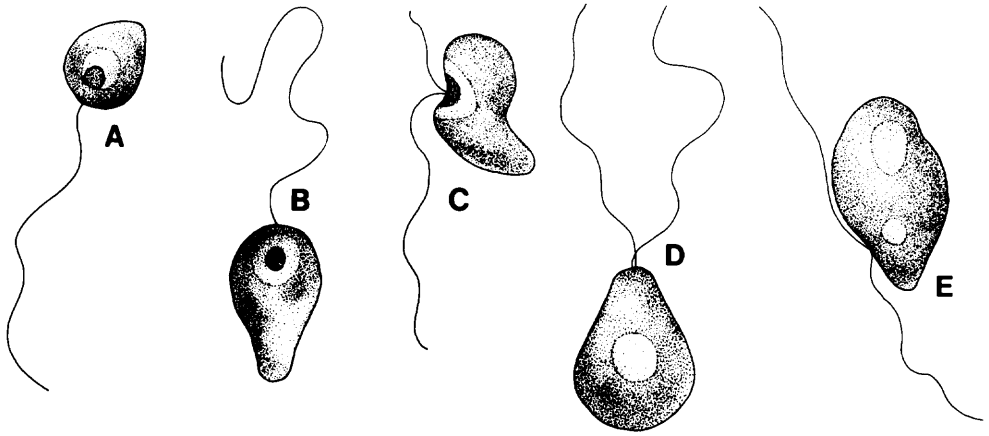

Fig. 1. Zoospore types. A. Posteriorly uniflagellate, whiplash type (Chytridiomycetes). B. Anteriorly uniflagellate, tinsel type (Hyphochytridiomycetes). C. Laterally unequally biflagellate, one tinsel and one whiplash type (Oomycetes). D. Anteriorly biflagellate, both whiplash type (Plasmodiophoromycetes). E. Anteriorly and laterally equally biflagellate, one tinsel and one whiplash type (Oomycetes) (only lateral are illustrated).

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CHARACTERIZATION: All of the fungi that utilize zoospores to parasitize prey are classified in the division Mastigomycotina (Table 1). Five types of zoospores (Fig. 1) are found in this division, three of which are known from the nematophagous species. Zoospores are usually produced in a well-defined flask-shaped zoosporangium (Fig. 2-D) either in or out of the host body. Internal zoosporangia are usually catenulate, set off by septations (Fig. 2-D). Some forms such as Lagenidium caudatum produce modified hyphae that serve as zoosporangia. Zoosporangia usually produce short or very long zoospore evacuation tubes that in most cases penetrate the host integument. Zoospores emerge from the evacuation tube mouth. Oogonia are also produced by zoosporic fungi to insure survival during adverse conditions (Fig. 3).

ENTRAPMENT: Most liberated zoospores swim to their prey and attach to the integument (Fig. 4-right) which is then penetrated by an infection peg. Some forms such as Myzocytium anomalum produce aplanospores (flagella absent), that develop into flagellated zoospores when conditions are favorable. Other species such as M. glutinosporum and M. humicola produce encysted zoospores that germinate to produce one or more spherical adhesive buds. The buds attach to passing nematodes and infect the nematode internally (Fig. 4-left). Zoospores of Catenaria anguillulae attach in clusters, and have a special affinity to body openings of its host (Fig. 5). Rhizophydium sp., which has been observed attached to Criconemoides sp. and the eggs of Verutus volvingentis Esser, 1981, forms zoosporangia external to the body of its host (Fig. 6).

HABITAT: Although zoosporic fungi are traditionally considered aquatic, many are commonly associated with moist soils. However, the fungus Saprolegnia megasperma occurs in fresh running water and parasitizes the nematode Neomesomermis flumeralis (Welch 1967) Nickle, 1972, which in turn parasitizes blackflies.

HOSTS: Catenaria anguillulae has the widest host range, infecting 25 genera and 27 species of nematodes most of which are phytoparasites (7). Catenaria vermicola has been reported parasitizing 10 genera and 9 species of phytoparasites (5), and C. auxiliaris was found in cysts of Globodera pallida (Stone, 1973) Mulvey & Stone, 1976, Heterodera avenae (Wollenweber, 1924) Filipjev, 1934, and H. schachtii A. Schmidt, 1971 (11). Lagenidium parthenosporum was detected in cysts of Heterodera sp. (10), Nematophthora gynophila in H. avenae cysts, and Olpidium nematodeae in H. schachtii cysts.

LIFE CYCLE: Twenty-five to eighty hours elapse from the time of zoospore attachment to the time of new zoospore production in Catenaria anguillulae. Fig. 2 shows the life cycle stages in Macroposthonia sphaerocephala (Taylor, 1936) de Grisse & Loof, 1965.

BIOLOGICAL CONTROL POTENTIAL: Catenaria anguillulae and C. vermicola attack and kill many kinds of phytoparasitic nematodes. Catenaria anguillulae will destroy most of the susceptible phytoparasites in culture in a few days. Species of Catenaria are not uncommon in random soil samples examined in the laboratory. A Lagenidium species that very closely resembles L. caudatum was discovered attacking Belonolaimus longicaudatus Rau, 1958, and Hoplolaimus tylenchiformis Daday, 1905 (Fig. 7). Only phytoparasites were noted infected by this fungus. The infection was epizootic in the populations observed. The actual biological control potential by zoosporic fungi appears very promising but is untested. Sting nematodes infected with C. anguillulae averaged 78 zoosporangia per specimen, with an average of 118 zoospores per zoosporangia, or 9,204 zoospores from a single infected sting nematode (7).

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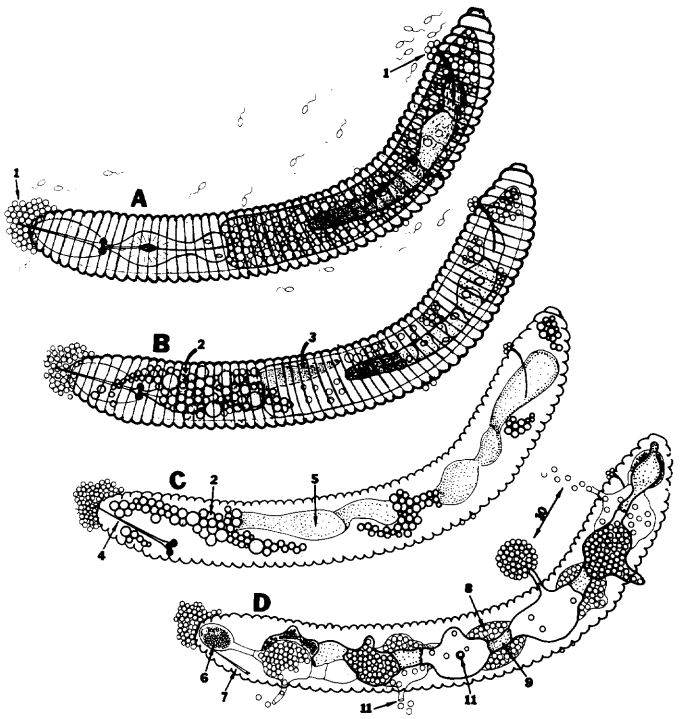
Figure 2. Life cycle of Catenaria anguillulae on and in Macroposthonia sphaerocephala: A) Infection (1 hr), (1) attached infective zoospores, B) Thallus appearance, nematode body content disruption (8 hr), (2) oil globules leaking from intestine into esophageal area, (3) young thallus; C) Thallus development (24 hr), (2) oil globules, (4) stylet fallen to side due to supportive tissue dissolution, (5) well-developed thallus; D) Two chains of mature and immature zoosporangia (36 hr), (6) immature zoosporangia, (7) stylet tip (meso-meta-, and telorhabdions disintegrated), (8) mature zoosporangium, (9) isthmus, (10) zoospore release, (11) escape pore of zoosporangium.



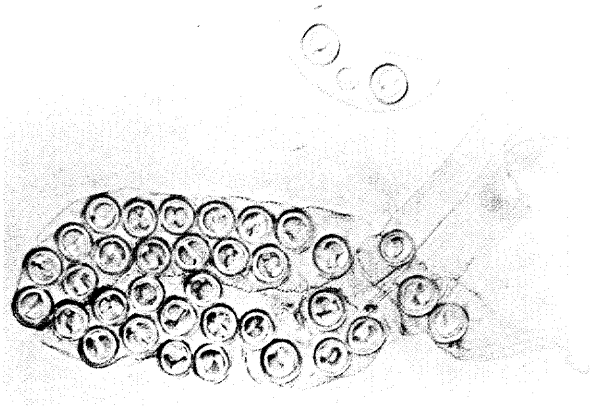


Figure 3. Oospores in Helicotylenchus sp.

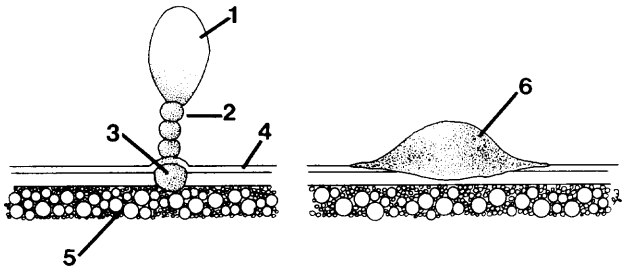


Figure 4. A zoospore attached to the integument of a nematode (right). A zoospore attached to its host by a mucilaginous bud (left). (1) Evacuating zoospore, (2) mucilaginous bud, (3) infection peg, (4) host integument, (5) host gut, (6) attached zoospore. (Drawings Credit: Linda Writer)

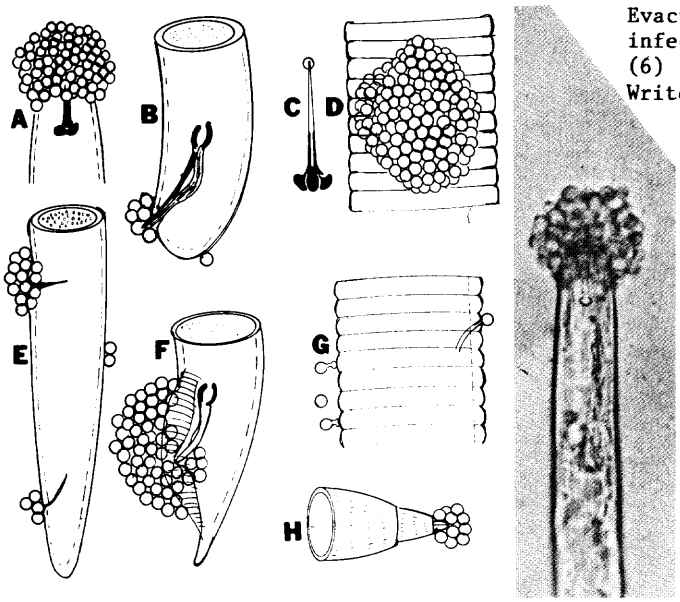


Figure 5. Zoospore attraction sites: A) mouth; B) F) cloaca; C) stylet tip; D) integument, vulva and anus; G) excretory pore; H) tail tip; I) photo of zoospores clustered on the head of Pratylenchus sp.

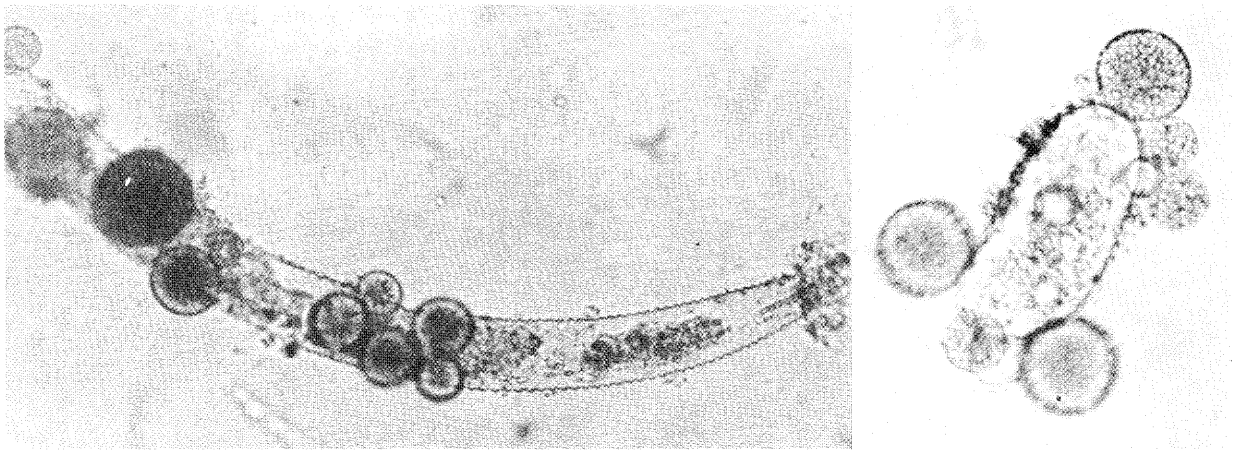


Figure 6. Rhizophidium sp. zoosporangia attached externally to an egg of Verutus volvingentis Esser, 1981, left, and to the body of Criconemoides sp.

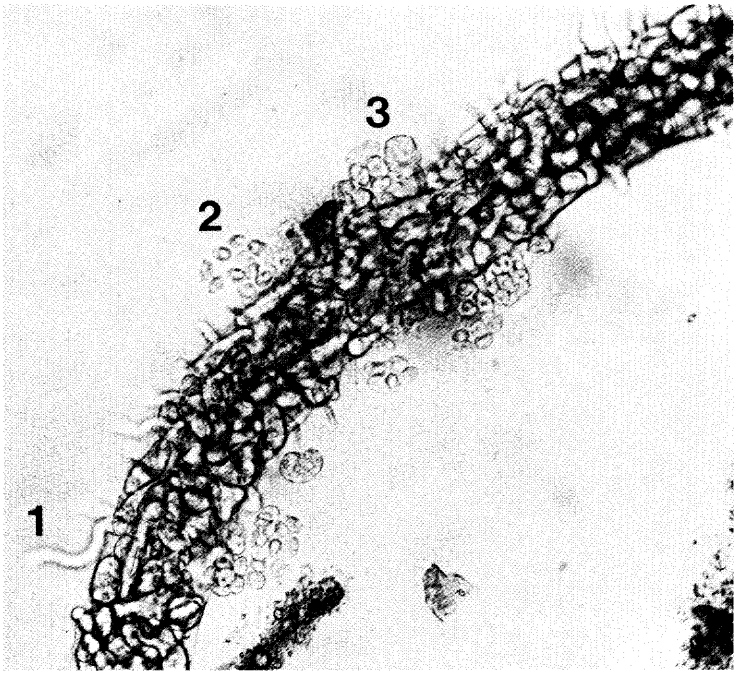


Figure 7. Hoplolaimus infected with coarse hyphae of Lagenidium. 1) Evacuation tube, 2) zoospore liberation, 3) zoospore cluster.

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